

Magnetizabilities of relativistic hydrogenlike atoms in some arbitrary discrete energy eigenstates

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Abstract

We present the results of numerical calculations of magnetizability (χ) of the relativistic one-electron atoms with a pointlike, spinless and motionless nuclei of charge Ze . Exploiting the analytical formula for χ recently derived by us [P. Stefańska, 2015], valid for an arbitrary discrete energy eigenstate, we have found the values of the magnetizability for the ground state and for the first and the second set of excited states (i.e.: $2s_{1/2}$, $2p_{1/2}$, $2p_{3/2}$, $3s_{1/2}$, $3p_{1/2}$, $3p_{3/2}$, $3d_{3/2}$, and $3d_{5/2}$) of the Dirac one-electron atom. The results for ions with the atomic number $1 \leq Z \leq 137$ are given in 14 tables. The comparison of the numerical values of magnetizabilities for the ground state and for each states belonging to the first set of excited states of selected hydrogenlike ions, obtained with the use of two different values of the fine-structure constant, i.e.: $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014) and $\alpha^{-1} = 137.035\,999\,074$ (CODATA 2010), is also presented.

Keywords: Hydrogenlike atom, Magnetizability, Electromagnetic moments, Dipole moment, Magnetic field.

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Introduction

Interaction of atoms and molecules with electromagnetic field is undoubtedly one of the most commonly reported physical processes, both theoretically and experimentally. For the simplest systems, like one-electron atoms, there are some analytical methods of calculating many atomic parameters, such as the polarizability or the magnetizability. One of such useful tool is the Sturmian expansion of the first-order generalized Dirac–Coulomb Green function [1], proposed by Szmytkowski in 1997. In the series of papers [2–9] published by his group over the period of past several years, it has been used in perturbation-theory calculations of some electromagnetic properties of the relativistic hydrogenlike atoms in the ground state, with a poinlike, spinless and motionless nuclei of charge Ze .

Recently, we have shown that the usefulness of this method goes beyond the study of the atomic ground state. In Ref. [10] we derived analytically an expression for the magnetizability of the Dirac one-electron atom (with regard to its nucleus we impose the same assumptions as above) in an arbitrary discrete energy eigenstate, characterized by the set of quantum numbers $\{n, \kappa, \mu\}$, in which n denotes the radial quantum number, the Dirac quantum number κ is an integer different from zero, whereas $\mu = -|\kappa| + \frac{1}{2}, -|\kappa| + \frac{3}{2}, \dots, |\kappa| - \frac{1}{2}$ is the magnetic quantum number. The final result has the following form:

$$\begin{aligned} \chi \equiv \chi_{n\kappa\mu} = & \frac{\alpha^2 a_0^3}{Z^2} \frac{1}{128(4\kappa^2 - 1)^2 N_{n\kappa}} \left\{ \Theta_{n\kappa\mu}^{(I)} + \sum_{\kappa'} \frac{\eta_{\kappa\mu}^{(+)} \delta_{\kappa', -\kappa+1} + \eta_{\kappa\mu}^{(-)} \delta_{\kappa', -\kappa-1}}{N_{n\kappa} + \kappa'} \right. \\ & \times \left[\Theta_{n\kappa}^{(II)} + \frac{n!(n^2 + 2n\gamma_\kappa + \kappa^2)\Gamma(n + 2\gamma_\kappa + 1)}{(N_{n\kappa} - \kappa)(\gamma_{\kappa'} - \gamma_\kappa - n + 1)\Gamma(2\gamma_{\kappa'} + 1)} \sum_{k=0}^n \sum_{p=0}^n \tilde{\mathcal{Z}}_{\kappa\kappa'}^n(k) \tilde{\mathcal{Z}}_{\kappa\kappa'}^n(p) \right. \\ & \left. \left. \times {}_3F_2 \left(\begin{matrix} \gamma_{\kappa'} - \gamma_\kappa - k - 1, \gamma_{\kappa'} - \gamma_\kappa - p - 1, \gamma_{\kappa'} - \gamma_\kappa - n + 1 \\ \gamma_{\kappa'} - \gamma_\kappa - n + 2, 2\gamma_{\kappa'} + 1 \end{matrix} ; 1 \right) \right] \right\}, \end{aligned} \quad (1)$$

where α is the Sommerfeld's fine structure constant, $\Gamma(\zeta)$ denotes the Euler's gamma function, ${}_3F_2$ is the generalized hypergeometric function, while

$$\eta_{\kappa\mu}^{(\pm)} = (4\kappa^2 - 1)^2 - 4\mu^2(2\kappa \pm 1)^2, \quad (2)$$

$$\Theta_{n\kappa\mu}^{(I)} = -256\kappa^2\mu^2 \left[2\kappa^2(n + \gamma_\kappa)^3 + (n + \gamma_\kappa)(5n^2 + 10n\gamma_\kappa + 2\gamma_\kappa^2 - 2\kappa^2 + 1)N_{n\kappa}^2 - \kappa(3n^2 + 6n\gamma_\kappa + 4\gamma_\kappa^2 - \kappa^2)N_{n\kappa} \right], \quad (3)$$

$$\Theta_{n\kappa}^{(II)} = 2(2n + 2\gamma_\kappa + 1)(\kappa - N_{n\kappa})N_{n\kappa}^2 \left[5(n + \gamma_\kappa)(n + \gamma_\kappa + 1) - 3(\gamma_\kappa^2 - 1) \right], \quad (4)$$

$$\tilde{\mathcal{Z}}_{\kappa\kappa'}^n(k) = \frac{(-)^k [2(N_{n\kappa} - \kappa) + (n - k)(\kappa + \kappa')]}{k!(n - k)!} \frac{\Gamma(\gamma_\kappa + \gamma_{\kappa'} + k + 2)}{\Gamma(k + 2\gamma_\kappa + 1)} \quad (5)$$

and analogously for $\tilde{\mathcal{Z}}_{\kappa\kappa'}^n(p)$, with

$$N_{n\kappa} = \sqrt{n^2 + 2n\gamma_\kappa + \kappa^2}, \quad (6)$$

and

$$\gamma_\kappa = \sqrt{\kappa^2 - (\alpha Z)^2}. \quad (7)$$

The above result has been exhaustively verified by us, both analytically and numerically. In Ref. [10] we have shown that it remains valid for *an arbitrary* discrete energy eigenstate. However, the aforementioned article contains only two representational tables with values of the relativistic magnetizabilities for some excited states of selected hydrogenlike ions. In this work, we present a more comprehensive numerical data in the form of 14 tables comprising the results for

the atomic ground state $1s_{1/2}$ and for each state belonging to the first and second set of excited states, i.e.: $2s_{1/2}$, $2p_{1/2}$, $2p_{3/2}$, $3s_{1/2}$, $3p_{1/2}$, $3p_{3/2}$, $3d_{3/2}$ and $3d_{5/2}$, having regard all possible values of the magnetic quantum number.

Present calculations have been performed with the current value 137.035 999 139 of the inverse of the fine-structure constant recommended by the Committee on Data for Science and Technology (CODATA) [11], in contrast to those described in Ref. [10], in which we have used $\alpha^{-1} = 137.035\,98\,95$ (CODATA 1986), to be able to compare our results with the previous results of other authors [12]. To show how the change in the value of the fine structure constant affects the value of the magnetizability, additionally, we performed calculations for χ with $\alpha^{-1} = 137.035\,999\,074$, recommended by CODATA 2010 (i.e. immediately before the currently valid value of this constant) and compared them with the corresponding values from Tables 1 – 5. The appropriate juxtaposition of numerical values of χ for the ground state and the first excited states of selected hydrogenlike ions are shown in Table 15.

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Explanation of Tables

In all the tables we have used the following notation:

χ	the atomic magnetizability
Z	the atomic number
α	the fine structure constant
a_0	the Bohr radius
$a(b)$	this means $a \times 10^b$
μ	the magnetic quantum number; $\mu = -j, \dots, j$

The atomic states are referred to as $\mathcal{N}x_j$, due to the following guidelines:

\mathcal{N}	the principal quantum number
$\mathcal{N} = n + \kappa $	Note that for the radial quantum number $n = 0$, κ is the negative integer!
κ	the Dirac quantum number; $\kappa = (l - j)(2j + 1)$
j	the total angular momentum quantum number; $j = \kappa - \frac{1}{2} = l \pm \frac{1}{2}$
$x \equiv s$	states with the orbital angular momentum quantum number $l = 0$
$x \equiv p$	states with the orbital angular momentum quantum number $l = 1$
$x \equiv d$	states with the orbital angular momentum quantum number $l = 2$

Table 1

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) for the ground state ($1s_{1/2}$) of hydrogenlike atoms, obtained with $\alpha^{-1} = 137.035999139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-4.999 644 993 669(-1)	47	-1.914 539 761 522(-4)	93	-2.485 921 010 714(-5)
2	-1.249 645 001 764(-1)	48	-1.821 478 207 432(-4)	94	-2.369 686 853 502(-5)
3	-5.552 005 708 136(-2)	49	-1.734 078 279 628(-4)	95	-2.257 394 374 192(-5)
4	-3.121 450 341 512(-2)	50	-1.651 892 129 562(-4)	96	-2.148 886 006 463(-5)
5	-1.996 450 584 458(-2)	51	-1.574 515 385 043(-4)	97	-2.044 012 432 389(-5)
6	-1.385 339 770 334(-2)	52	-1.501 582 182 786(-4)	98	-1.942 632 090 285(-5)
7	-1.016 859 395 768(-2)	53	-1.432 760 850 756(-4)	99	-1.844 610 718 053(-5)
8	-7.777 016 376 682(-3)	54	-1.367 750 144 935(-4)	100	-1.749 820 929 318(-5)
9	-6.137 360 476 020(-3)	55	-1.306 275 960 639(-4)	101	-1.658 141 819 878(-5)
10	-4.964 526 105 003(-3)	56	-1.248 088 451 191(-4)	102	-1.569 458 602 238(-5)
11	-4.096 763 187 651(-3)	57	-1.192 959 497 297(-4)	103	-1.483 662 266 206(-5)
12	-3.436 760 225 738(-3)	58	-1.140 680 479 176(-4)	104	-1.400 649 263 726(-5)
13	-2.923 124 649 789(-3)	59	-1.091 060 310 748(-4)	105	-1.320 321 216 323(-5)
14	-2.515 572 485 422(-3)	60	-1.043 923 701 231(-4)	106	-1.242 584 643 679(-5)
15	-2.186 782 153 895(-3)	61	-9.991 096 145 807(-5)	107	-1.167 350 712 035(-5)
16	-1.917 693 332 212(-3)	62	-9.564 699 014 466(-5)	108	-1.094 535 001 293(-5)
17	-1.694 681 086 002(-3)	63	-9.158 680 819 165(-5)	109	-1.024 057 289 792(-5)
18	-1.507 796 651 860(-3)	64	-8.771 782 603 565(-5)	110	-9.558 413 559 454(-6)
19	-1.349 638 371 108(-3)	65	-8.402 841 562 093(-5)	111	-8.898 147 960 202(-6)
20	-1.214 607 414 490(-3)	66	-8.050 782 368 085(-5)	112	-8.259 088 575 604(-6)
21	-1.098 405 408 420(-3)	67	-7.714 609 401 184(-5)	113	-7.640 582 880 810(-6)
22	-9.976 881 098 837(-4)	68	-7.393 399 769 008(-5)	114	-7.042 011 988 848(-6)
23	-9.098 220 947 731(-4)	69	-7.086 297 031 681(-5)	115	-6.462 789 440 666(-6)
24	-8.327 108 732 660(-4)	70	-6.792 505 549 481(-5)	116	-5.902 360 150 332(-6)
25	-7.646 686 812 239(-4)	71	-6.511 285 383 916(-5)	117	-5.360 199 511 955(-6)
26	-7.043 275 730 781(-4)	72	-6.241 947 691 165(-5)	118	-4.835 812 678 917(-6)
27	-6.505 681 398 115(-4)	73	-5.983 850 554 327(-5)	119	-4.328 734 031 249(-6)
28	-6.024 672 275 918(-4)	74	-5.736 395 207 348(-5)	120	-3.838 526 853 900(-6)
29	-5.592 580 513 314(-4)	75	-5.499 022 609 171(-5)	121	-3.364 783 257 947(-6)
30	-5.202 994 550 774(-4)	76	-5.271 210 331 468(-5)	122	-2.907 124 389 732(-6)
31	-4.850 519 982 467(-4)	77	-5.052 469 727 622(-5)	123	-2.465 200 991 082(-6)
32	-4.530 591 888 651(-4)	78	-4.842 343 354 310(-5)	124	-2.038 694 400 207(-6)
33	-4.239 326 356 104(-4)	79	-4.640 402 620 272(-5)	125	-1.627 318 121 987(-6)
34	-3.973 402 106 035(-4)	80	-4.446 245 639 716(-5)	126	-1.230 820 156 192(-6)
35	-3.729 965 449 227(-4)	81	-4.259 495 270 292(-5)	127	-8.489 863 663 198(-7)
36	-3.506 553 458 869(-4)	82	-4.079 797 317 743(-5)	128	-4.816 453 253 524(-7)
37	-3.301 031 476 936(-4)	83	-3.906 818 891 304(-5)	129	-1.286 753 358 938(-7)
38	-3.111 541 977 427(-4)	84	-3.740 246 895 575(-5)	130	2.099 852 117 594(-7)
39	-2.936 462 487 550(-4)	85	-3.579 786 646 142(-5)	131	5.343 220 977 306(-7)
40	-2.774 370 778 562(-4)	86	-3.425 160 597 514(-5)	132	8.442 203 047 896(-7)
41	-2.624 015 925 544(-4)	87	-3.276 107 173 135(-5)	133	1.139 421 970 186(-6)
42	-2.484 294 131 889(-4)	88	-3.132 379 688 278(-5)	134	1.419 449 261 336(-6)
43	-2.354 228 442 610(-4)	89	-2.993 745 357 549(-5)	135	1.683 443 662 506(-6)
44	-2.232 951 647 654(-4)	90	-2.859 984 379 546(-5)	136	1.929 752 760 437(-6)
45	-2.119 691 814 557(-4)	91	-2.730 889 091 984(-5)	137	2.154 582 953 028(-6)
46	-2.013 759 998 257(-4)	92	-2.606 263 191 219(-5)		

Table 2

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $2s_{1/2}$, obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-6.999 722 649 147(+0)	47	-2.891 300 079 244(-3)	93	-5.295 132 413 795(-4)
2	-1.749 722 649 002(+0)	48	-2.760 626 290 162(-3)	94	-5.122 608 926 758(-4)
3	-7.775 004 265 370(-1)	49	-2.637 869 458 376(-3)	95	-4.955 404 845 206(-4)
4	-4.372 226 484 179(-1)	50	-2.522 402 512 753(-3)	96	-4.793 293 766 449(-4)
5	-2.797 226 479 764(-1)	51	-2.413 659 246 069(-3)	97	-4.636 060 481 284(-4)
6	-1.941 670 918 773(-1)	52	-2.311 127 360 473(-3)	98	-4.483 500 254 287(-4)
7	-1.425 797 896 419(-1)	53	-2.214 342 422 647(-3)	99	-4.335 418 150 281(-4)
8	-1.090 976 460 292(-1)	54	-2.122 882 595 177(-3)	100	-4.191 628 402 646(-4)
9	-8.614 239 824 945(-2)	55	-2.036 364 032 257(-3)	101	-4.051 953 819 423(-4)
10	-6.972 264 418 235(-2)	56	-1.954 436 845 705(-3)	102	-3.916 225 223 358(-4)
11	-5.757 388 275 239(-2)	57	-1.876 781 561 951(-3)	103	-3.784 280 922 233(-4)
12	-4.833 375 297 132(-2)	58	-1.803 106 002 867(-3)	104	-3.655 966 205 901(-4)
13	-4.114 275 885 212(-2)	59	-1.733 142 533 473(-3)	105	-3.531 132 866 548(-4)
14	-3.543 692 473 776(-2)	60	-1.666 645 628 015(-3)	106	-3.409 638 738 663(-4)
15	-3.083 374 850 888(-2)	61	-1.603 389 712 992(-3)	107	-3.291 347 255 127(-4)
16	-2.706 638 562 519(-2)	62	-1.543 167 251 719(-3)	108	-3.176 127 015 690(-4)
17	-2.394 408 698 585(-2)	63	-1.485 787 039 964(-3)	109	-3.063 851 363 791(-4)
18	-2.132 756 988 218(-2)	64	-1.431 072 686 523(-3)	110	-2.954 397 967 327(-4)
19	-1.911 321 107 028(-2)	65	-1.378 861 256 103(-3)	111	-2.847 648 398 359(-4)
20	-1.722 262 691 678(-2)	66	-1.329 002 055 036(-3)	112	-2.743 487 706 001(-4)
21	-1.559 564 016 628(-2)	67	-1.281 355 542 857(-3)	113	-2.641 803 975 620(-4)
22	-1.418 543 138 991(-2)	68	-1.235 792 355 067(-3)	114	-2.542 487 866 056(-4)
23	-1.295 513 262 209(-2)	69	-1.192 192 424 289(-3)	115	-2.445 432 114 536(-4)
24	-1.187 539 297 571(-2)	70	-1.150 444 188 624(-3)	116	-2.350 530 996 246(-4)
25	-1.092 261 172 173(-2)	71	-1.110 443 877 486(-3)	117	-2.257 679 721 772(-4)
26	-1.007 763 758 957(-2)	72	-1.072 094 866 329(-3)	118	-2.166 773 750 318(-4)
27	-9.324 798 818 781(-3)	73	-1.035 307 092 789(-3)	119	-2.077 707 989 250(-4)
28	-8.651 171 219 921(-3)	74	-9.999 965 276 428(-4)	120	-1.990 375 839 852(-4)
29	-8.046 019 764 341(-3)	75	-9.660 846 947 558(-4)	121	-1.904 668 033 712(-4)
30	-7.500 368 229 614(-3)	76	-9.334 982 349 096(-4)	122	-1.820 471 181 228(-4)
31	-7.006 664 406 792(-3)	77	-9.021 685 089 679(-4)	123	-1.737 665 918 852(-4)
32	-6.558 517 365 714(-3)	78	-8.720 312 363 693(-4)	124	-1.656 124 487 687(-4)
33	-6.150 489 583 572(-3)	79	-8.430 261 653 873(-4)	125	-1.575 707 489 732(-4)
34	-5.777 931 223 941(-3)	80	-8.150 967 719 944(-4)	126	-1.496 259 425 995(-4)
35	-5.436 847 073 938(-3)	81	-7.881 899 845 170(-4)	127	-1.417 602 378 199(-4)
36	-5.123 788 986 136(-3)	82	-7.622 559 315 742(-4)	128	-1.339 526 764 241(-4)
37	-4.835 768 387 453(-3)	83	-7.372 477 110 602(-4)	129	-1.261 777 290 721(-4)
38	-4.570 184 687 625(-3)	84	-7.131 211 781 713(-4)	130	-1.184 030 625 960(-4)
39	-4.324 766 368 820(-3)	85	-6.898 347 506 852(-4)	131	-1.105 857 907 160(-4)
40	-4.097 522 252 752(-3)	86	-6.673 492 298 868(-4)	132	-1.026 657 241 129(-4)
41	-3.886 700 984 303(-3)	87	-6.456 276 356 981(-4)	133	-9.455 204 905 699(-5)
42	-3.690 757 185 747(-3)	88	-6.246 350 547 147(-4)	134	-8.609 343 611 784(-5)
43	-3.508 323 055 315(-3)	89	-6.043 384 999 803(-4)	135	-7.699 646 244 933(-5)
44	-3.338 184 431 761(-3)	90	-5.847 067 814 448(-4)	136	-6.650 881 273 142(-5)
45	-3.179 260 540 006(-3)	91	-5.657 103 861 534(-4)	137	-4.903 302 713 912(-5)
46	-3.030 586 784 802(-3)	92	-5.473 213 673 024(-4)		

Table 3

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $2p_{1/2}$, obtained with $\alpha^{-1} = 137.035999139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	6.676 163 152 752(+4)	47	1.041 492 649 963(−2)	93	2.075 091 052 946(−4)
2	4.171 164 660 772(+3)	48	9.452 888 853 908(−3)	94	1.888 736 138 669(−4)
3	8.234 606 720 151(+2)	49	8.591 529 248 763(−3)	95	1.715 865 142 938(−4)
4	2.603 386 065 977(+2)	50	7.818 803 550 735(−3)	96	1.555 531 822 422(−4)
5	1.065 244 131 032(+2)	51	7.124 297 098 369(−3)	97	1.406 862 128 024(−4)
6	5.130 676 007 305(+1)	52	6.498 978 907 081(−3)	98	1.269 048 169 139(−4)
7	2.765 269 415 830(+1)	53	5.934 996 687 137(−3)	99	1.141 342 734 163(−4)
8	1.618 150 944 960(+1)	54	5.425 505 295 092(−3)	100	1.023 054 311 643(−4)
9	1.008 224 808 325(+1)	55	4.964 522 679 064(−3)	101	9.135 425 625 123(−5)
10	6.600 466 097 095(+0)	56	4.546 808 517 220(−3)	102	8.122 141 992 195(−5)
11	4.497 274 971 042(+0)	57	4.167 761 653 933(−3)	103	7.185 192 323 468(−5)
12	3.166 932 216 060(+0)	58	3.823 333 160 207(−3)	104	6.319 475 495 001(−5)
13	2.292 616 774 375(+0)	59	3.509 952 423 720(−3)	105	5.520 257 950 219(−5)
14	1.699 146 904 160(+0)	60	3.224 464 139 363(−3)	106	4.783 145 224 150(−5)
15	1.285 028 571 997(+0)	61	2.964 074 447 113(−3)	107	4.104 055 943 473(−5)
16	9.890 736 419 919(−1)	62	2.726 304 768 887(−3)	108	3.479 198 077 905(−5)
17	7.731 059 146 983(−1)	63	2.508 952 143 920(−3)	109	2.905 047 242 532(−5)
18	6.125 838 134 843(−1)	64	2.310 055 064 618(−3)	110	2.378 326 872 591(−5)
19	4.913 104 810 651(−1)	65	2.127 863 980 587(−3)	111	1.895 990 112 171(−5)
20	3.983 443 339 545(−1)	66	1.960 815 774 794(−3)	112	1.455 203 276 815(−5)
21	3.261 385 629 899(−1)	67	1.807 511 628 042(−3)	113	1.053 330 767 350(−5)
22	2.693 897 023 870(−1)	68	1.666 697 780 826(−3)	114	6.879 213 289 411(−6)
23	2.243 073 696 744(−1)	69	1.537 248 778 577(−3)	115	3.566 955 658 159(−6)
24	1.881 407 837 991(−1)	70	1.418 152 850 346(−3)	116	5.753 463 894 641(−7)
25	1.588 655 676 583(−1)	71	1.308 499 124 331(−3)	117	−2.115 299 080 229(−6)
26	1.349 727 657 448(−1)	72	1.207 466 428 302(−3)	118	−4.523 252 290 108(−6)
27	1.153 243 297 378(−1)	73	1.114 313 460 394(−3)	119	−6.665 451 722 083(−6)
28	9.905 260 581 612(−2)	74	1.028 370 147 165(−3)	120	−8.557 571 732 907(−6)
29	8.548 943 353 449(−2)	75	9.490 300 323 220(−4)	121	−1.021 407 985 150(−5)
30	7.411 547 649 680(−2)	76	8.757 435 618 780(−4)	122	−1.164 828 128 722(−5)
31	6.452 357 143 356(−2)	77	8.080 121 504 470(−4)	123	−1.287 234 869 347(−5)
32	5.639 191 775 860(−2)	78	7.453 829 294 325(−4)	124	−1.389 733 402 654(−5)
33	4.946 425 903 654(−2)	79	6.874 440 915 371(−4)	125	−1.473 315 745 991(−5)
34	4.353 508 886 238(−2)	80	6.338 207 576 445(−4)	126	−1.538 856 526 852(−5)
35	3.843 850 568 001(−2)	81	5.841 713 020 641(−4)	127	−1.587 104 346 068(−5)
36	3.403 974 400 708(−2)	82	5.381 840 806 272(−4)	128	−1.618 666 488 046(−5)
37	3.022 868 709 620(−2)	83	4.955 745 134 059(−4)	129	−1.633 983 071 444(−5)
38	2.691 485 942 864(−2)	84	4.560 824 800 844(−4)	130	−1.633 283 429 506(−5)
39	2.402 353 358 305(−2)	85	4.194 699 913 940(−4)	131	−1.616 510 518 910(−5)
40	2.149 268 284 498(−2)	86	3.855 191 046 650(−4)	132	−1.583 182 968 338(−5)
41	1.927 058 043 264(−2)	87	3.540 300 555 545(−4)	133	−1.532 122 229 934(−5)
42	1.731 389 656 364(−2)	88	3.248 195 814 763(−4)	134	−1.460 843 494 070(−5)
43	1.558 618 136 759(−2)	89	2.977 194 152 621(−4)	135	−1.363 909 968 444(−5)
44	1.405 664 873 271(−2)	90	2.725 749 301 911(−4)	136	−1.226 629 949 283(−5)
45	1.269 919 627 128(−2)	91	2.492 439 197 909(−4)	137	−9.398 566 990 645(−6)
46	1.149 161 160 811(−2)	92	2.275 954 977 863(−4)		

Table 4

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $2p_{3/2}$ ($\mu = \pm 1/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-6.677 063 123 774(+4)	47	-1.419 858 008 271(-2)	93	-9.520 247 585 051(-4)
2	-4.173 414 370 995(+3)	48	-1.306 850 716 417(-2)	94	-9.110 967 976 025(-4)
3	-8.244 603 822 364(+2)	49	-1.204 929 044 477(-2)	95	-8.721 966 496 674(-4)
4	-2.609 008 168 169(+2)	50	-1.112 807 953 802(-2)	96	-8.352 003 098 775(-4)
5	-1.068 841 233 198(+2)	51	-1.029 373 178 218(-2)	97	-7.999 924 087 903(-4)
6	-5.155 647 028 648(+1)	52	-9.536 557 503 502(-3)	98	-7.664 655 136 787(-4)
7	-2.783 607 783 733(+1)	53	-8.848 107 262 219(-3)	99	-7.345 194 910 790(-4)
8	-1.632 184 465 485(+1)	54	-8.220 993 530 005(-3)	100	-7.040 609 243 754(-4)
9	-1.019 306 939 462(+1)	55	-7.648 740 715 368(-3)	101	-6.750 025 808 723(-4)
10	-6.690 176 291 750(+0)	56	-7.125 658 615 537(-3)	102	-6.472 629 233 627(-4)
11	-4.571 365 324 767(+0)	57	-6.646 735 297 241(-3)	103	-6.207 656 616 747(-4)
12	-3.229 142 397 650(+0)	58	-6.207 546 146 715(-3)	104	-5.954 393 400 982(-4)
13	-2.345 581 386 355(+0)	59	-5.804 176 421 013(-3)	105	-5.712 169 569 462(-4)
14	-1.744 775 437 492(+0)	60	-5.433 155 109 121(-3)	106	-5.480 356 128 082(-4)
15	-1.324 738 729 201(+0)	61	-5.091 398 296 516(-3)	107	-5.258 361 842 946(-4)
16	-1.023 940 039 748(+0)	62	-4.776 160 539 216(-3)	108	-5.045 630 202 691(-4)
17	-8.039 579 208 388(-1)	63	-4.484 993 007 746(-3)	109	-4.841 636 576 980(-4)
18	-6.400 717 180 687(-1)	64	-4.215 707 369 325(-3)	110	-4.645 885 543 258(-4)
19	-5.159 513 442 642(-1)	65	-3.966 344 546 946(-3)	111	-4.457 908 353 960(-4)
20	-4.205 544 369 778(-1)	66	-3.735 147 634 167(-3)	112	-4.277 260 515 650(-4)
21	-3.462 568 162 852(-1)	67	-3.520 538 360 073(-3)	113	-4.103 519 449 886(-4)
22	-2.876 948 199 888(-1)	68	-3.321 096 594 543(-3)	114	-3.936 282 202 669(-4)
23	-2.410 306 639 419(-1)	69	-3.135 542 463 400(-3)	115	-3.775 163 164 680(-4)
24	-2.034 758 302 313(-1)	70	-2.962 720 709 108(-3)	116	-3.619 791 757 628(-4)
25	-1.729 755 979 538(-1)	71	-2.801 586 987 902(-3)	117	-3.469 810 031 876(-4)
26	-1.479 963 885 340(-1)	72	-2.651 195 840 403(-3)	118	-3.324 870 105 890(-4)
27	-1.273 800 042 385(-1)	73	-2.510 690 111 521(-3)	119	-3.184 631 356 651(-4)
28	-1.102 421 744 243(-1)	74	-2.379 291 628 090(-3)	120	-3.048 757 238 860(-4)
29	-9.590 093 645 933(-2)	75	-2.256 292 970 148(-3)	121	-2.916 911 564 274(-4)
30	-8.382 541 308 263(-2)	76	-2.141 050 195 036(-3)	122	-2.788 754 002 214(-4)
31	-7.359 873 103 395(-2)	77	-2.032 976 393 189(-3)	123	-2.663 934 454 106(-4)
32	-6.489 087 280 871(-2)	78	-1.931 535 971 212(-3)	124	-2.542 085 784 218(-4)
33	-5.743 859 086 216(-2)	79	-1.836 239 572 101(-3)	125	-2.422 814 112 148(-4)
34	-5.103 040 041 916(-2)	80	-1.746 639 554 569(-3)	126	-2.305 685 410 031(-4)
35	-4.549 526 321 186(-2)	81	-1.662 325 963 868(-3)	127	-2.190 206 345 130(-4)
36	-4.069 398 041 558(-2)	82	-1.582 922 935 355(-3)	128	-2.075 795 856 830(-4)
37	-3.651 259 282 147(-2)	83	-1.508 085 479 692(-3)	129	-1.961 741 195 534(-4)
38	-3.285 728 128 388(-2)	84	-1.437 496 605 132(-3)	130	-1.847 126 573 331(-4)
39	-2.965 039 784 717(-2)	85	-1.370 864 738 001(-3)	131	-1.730 710 455 245(-4)
40	-2.682 735 569 862(-2)	86	-1.307 921 407 350(-3)	132	-1.610 698 646 631(-4)
41	-2.433 417 630 171(-2)	87	-1.248 419 163 964(-3)	133	-1.484 282 849 689(-4)
42	-2.212 554 294 681(-2)	88	-1.192 129 707 603(-3)	134	-1.346 569 662 465(-4)
43	-2.016 324 714 763(-2)	89	-1.138 842 199 469(-3)	135	-1.187 541 215 741(-4)
44	-1.841 494 171 369(-2)	90	-1.088 361 739 674(-3)	136	-9.796 700 216 327(-5)
45	-1.685 313 467 441(-2)	91	-1.040 507 991 880(-3)	137	-4.903 236 487 356(-5)
46	-1.545 437 344 510(-2)	92	-9.951 139 393 523(-4)		

Table 5

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $2p_{3/2}$ ($\mu = \pm 3/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-5.999 861 546 894(+0)	47	-2.578 631 244 428(-3)	93	-5.589 508 155 663(-4)
2	-1.499 861 548 141(+0)	48	-2.466 676 723 115(-3)	94	-5.443 509 574 534(-4)
3	-6.665 282 168 857(-1)	49	-2.361 509 657 648(-3)	95	-5.302 132 488 766(-4)
4	-3.748 615 531 285(-1)	50	-2.262 592 588 983(-3)	96	-5.165 185 776 675(-4)
5	-2.398 615 568 695(-1)	51	-2.169 440 228 389(-3)	97	-5.032 488 119 440(-4)
6	-1.665 282 281 087(-1)	52	-2.081 613 496 469(-3)	98	-4.903 867 404 056(-4)
7	-1.223 105 464 382(-1)	53	-1.998 714 341 935(-3)	99	-4.779 160 168 287(-4)
8	-9.361 157 308 251(-2)	54	-1.920 381 225 688(-3)	100	-4.658 211 084 276(-4)
9	-7.393 565 422 485(-2)	55	-1.846 285 174 354(-3)	101	-4.540 872 477 769(-4)
10	-5.986 158 805 136(-2)	56	-1.776 126 322 645(-3)	102	-4.427 003 880 170(-4)
11	-4.944 837 364 403(-2)	57	-1.709 630 876 565(-3)	103	-4.316 471 610 890(-4)
12	-4.152 827 301 722(-2)	58	-1.646 548 439 917(-3)	104	-4.209 148 387 674(-4)
13	-3.536 457 532 962(-2)	59	-1.586 649 655 271(-3)	105	-4.104 912 962 780(-4)
14	-3.047 387 288 039(-2)	60	-1.529 724 117 834(-3)	106	-4.003 649 783 072(-4)
15	-2.652 830 671 566(-2)	61	-1.475 578 526 709(-3)	107	-3.905 248 672 245(-4)
16	-2.329 915 294 981(-2)	62	-1.424 035 043 188(-3)	108	-3.809 604 533 555(-4)
17	-2.062 291 236 005(-2)	63	-1.374 929 829 983(-3)	109	-3.716 617 071 546(-4)
18	-1.838 019 977 443(-2)	64	-1.328 111 748 960(-3)	110	-3.626 190 531 412(-4)
19	-1.648 219 527 707(-2)	65	-1.283 441 198 032(-3)	111	-3.538 233 454 717(-4)
20	-1.486 171 290 440(-2)	66	-1.240 789 070 458(-3)	112	-3.452 658 450 320(-4)
21	-1.346 717 216 017(-2)	67	-1.200 035 822 051(-3)	113	-3.369 381 979 421(-4)
22	-1.225 844 211 425(-2)	68	-1.161 070 633 696(-3)	114	-3.288 324 153 757(-4)
23	-1.120 392 166 266(-2)	69	-1.123 790 658 208(-3)	115	-3.209 408 546 024(-4)
24	-1.027 845 291 207(-2)	70	-1.088 100 341 950(-3)	116	-3.132 562 011 690(-4)
25	-9.461 806 676 594(-3)	71	-1.053 910 812 872(-3)	117	-3.057 714 521 429(-4)
26	-8.737 567 592 428(-3)	72	-1.021 139 327 613(-3)	118	-2.984 799 003 449(-4)
27	-8.092 302 733 582(-3)	73	-9.897 087 712 636(-4)	119	-2.913 751 195 060(-4)
28	-7.514 934 235 489(-3)	74	-9.595 472 041 212(-4)	120	-2.844 509 502 864(-4)
29	-6.996 260 657 708(-3)	75	-9.305 874 504 615(-4)	121	-2.777 014 871 002(-4)
30	-6.528 588 108 588(-3)	76	-9.027 667 249 364(-4)	122	-2.711 210 656 928(-4)
31	-6.105 443 280 080(-3)	77	-8.760 262 927 126(-4)	123	-2.647 042 514 230(-4)
32	-5.721 348 246 583(-3)	78	-8.503 111 599 116(-4)	124	-2.584 458 282 039(-4)
33	-5.371 642 289 456(-3)	79	-8.255 697 913 049(-4)	125	-2.523 407 880 602(-4)
34	-5.052 339 850 487(-3)	80	-8.017 538 525 544(-4)	126	-2.463 843 212 643(-4)
35	-4.760 016 478 053(-3)	81	-7.788 179 745 891(-4)	127	-2.405 718 070 138(-4)
36	-4.491 716 634 495(-3)	82	-7.567 195 379 726(-4)	128	-2.348 988 046 166(-4)
37	-4.244 878 703 764(-3)	83	-7.354 184 753 456(-4)	129	-2.293 610 451 532(-4)
38	-4.017 273 627 275(-3)	84	-7.148 770 902 326(-4)	130	-2.239 544 235 860(-4)
39	-3.806 954 409 320(-3)	85	-6.950 598 906 817(-4)	131	-2.186 749 912 890(-4)
40	-3.612 214 346 049(-3)	86	-6.759 334 363 662(-4)	132	-2.135 189 489 721(-4)
41	-3.431 552 297 178(-3)	87	-6.574 661 979 166(-4)	133	-2.084 826 399 770(-4)
42	-3.263 643 675 350(-3)	88	-6.396 284 273 783(-4)	134	-2.035 625 439 216(-4)
43	-3.107 316 102 083(-3)	89	-6.223 920 388 001(-4)	135	-1.987 552 706 735(-4)
44	-2.961 528 891 718(-3)	90	-6.057 304 980 587(-4)	136	-1.940 575 546 321(-4)
45	-2.825 355 690 580(-3)	91	-5.896 187 211 102(-4)	137	-1.894 662 493 029(-4)
46	-2.697 969 728 727(-3)	92	-5.740 329 799 424(-4)		

Table 6

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3s_{1/2}$, obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-3.449 899 704 639(+1)	47	-1.460 589 595 746(-2)	93	-2.938 787 161 517(-3)
2	-8.623 997 035 001(+0)	48	-1.396 150 304 355(-2)	94	-2.852 875 528 084(-3)
3	-3.832 330 349 350(+0)	49	-1.335 612 093 153(-2)	95	-2.769 568 453 095(-3)
4	-2.155 246 989 428(+0)	50	-1.278 665 898 809(-2)	96	-2.688 753 878 288(-3)
5	-1.378 996 955 223(+0)	51	-1.225 032 654 958(-2)	97	-2.610 325 233 432(-3)
6	-9.573 302 467 217(-1)	52	-1.174 459 864 603(-2)	98	-2.534 181 079 133(-3)
7	-7.030 784 965 588(-1)	53	-1.126 718 620 861(-2)	99	-2.460 224 772 109(-3)
8	-5.380 593 067 547(-1)	54	-1.081 601 010 268(-2)	100	-2.388 364 150 764(-3)
9	-4.249 226 678 373(-1)	55	-1.038 917 843 515(-2)	101	-2.318 511 239 016(-3)
10	-3.439 966 693 483(-1)	56	-9.984 966 672 575(-3)	102	-2.250 581 966 414(-3)
11	-2.841 205 559 773(-1)	57	-9.601 800 179 014(-3)	103	-2.184 495 902 683(-3)
12	-2.385 798 342 713(-1)	58	-9.238 238 842 908(-3)	104	-2.120 176 004 857(-3)
13	-2.031 384 168 537(-1)	59	-8.892 963 512 056(-3)	105	-2.057 548 375 164(-3)
14	-1.750 167 094 022(-1)	60	-8.564 763 997 698(-3)	106	-1.996 542 027 847(-3)
15	-1.523 295 228 857(-1)	61	-8.252 528 443 623(-3)	107	-1.937 088 662 980(-3)
16	-1.337 616 949 121(-1)	62	-7.955 233 885 600(-3)	108	-1.879 122 445 283(-3)
17	-1.183 731 048 967(-1)	63	-7.671 937 851 189(-3)	109	-1.822 579 785 735(-3)
18	-1.054 772 880 436(-1)	64	-7.401 770 870 923(-3)	110	-1.767 399 123 538(-3)
19	-9.456 352 977 531(-2)	65	-7.143 929 789 539(-3)	111	-1.713 520 705 675(-3)
20	-8.524 551 073 618(-2)	66	-6.897 671 781 034(-3)	112	-1.660 886 360 777(-3)
21	-7.722 664 300 383(-2)	67	-6.662 308 984 122(-3)	113	-1.609 439 263 445(-3)
22	-7.027 617 365 691(-2)	68	-6.437 203 685 646(-3)	114	-1.559 123 684 256(-3)
23	-6.421 239 627 038(-2)	69	-6.221 763 988 858(-3)	115	-1.509 884 719 554(-3)
24	-5.889 065 287 630(-2)	70	-6.015 439 911 547(-3)	116	-1.461 667 993 506(-3)
25	-5.419 462 557 019(-2)	71	-5.817 719 865 910(-3)	117	-1.414 419 322 728(-3)
26	-5.002 992 592 011(-2)	72	-5.628 127 478 035(-3)	118	-1.368 084 330 712(-3)
27	-4.631 931 450 713(-2)	73	-5.446 218 710 006(-3)	119	-1.322 607 994 990(-3)
28	-4.299 909 351 091(-2)	74	-5.271 579 252 139(-3)	120	-1.277 934 103 803(-3)
29	-4.001 635 454 512(-2)	75	-5.103 822 156 684(-3)	121	-1.234 004 590 068(-3)
30	-3.732 685 762 416(-2)	76	-4.942 585 687 741(-3)	122	-1.190 758 697 155(-3)
31	-3.489 338 111 317(-2)	77	-4.787 531 365 038(-3)	123	-1.148 131 910 811(-3)
32	-3.268 442 682 131(-2)	78	-4.638 342 181 782(-3)	124	-1.106 054 560 335(-3)
33	-3.067 319 549 254(-2)	79	-4.494 720 979 055(-3)	125	-1.064 449 942 217(-3)
34	-2.883 677 003 789(-2)	80	-4.356 388 961 144(-3)	126	-1.023 231 737 424(-3)
35	-2.715 545 972 578(-2)	81	-4.223 084 337 950(-3)	127	-9.823 003 535 377(-4)
36	-2.561 227 007 420(-2)	82	-4.094 561 082 102(-3)	128	-9.415 375 740 697(-4)
37	-2.419 247 164 455(-2)	83	-3.970 587 789 747(-3)	129	-9.007 984 322 462(-4)
38	-2.288 324 719 758(-2)	84	-3.850 946 635 148(-3)	130	-8.598 983 050 522(-4)
39	-2.167 340 134 934(-2)	85	-3.735 432 410 250(-3)	131	-8.185 912 607 096(-4)
40	-2.055 312 038 761(-2)	86	-3.623 851 641 304(-3)	132	-7.765 311 175 512(-4)
41	-1.951 377 258 400(-2)	87	-3.516 021 775 421(-3)	133	-7.331 946 777 324(-4)
42	-1.854 774 138 255(-2)	88	-3.411 770 430 663(-3)	134	-6.877 096 795 936(-4)
43	-1.764 828 542 120(-2)	89	-3.310 934 703 898(-3)	135	-6.383 858 465 176(-4)
44	-1.680 942 056 420(-2)	90	-3.213 360 531 211(-3)	136	-5.808 962 689 597(-4)
45	-1.602 582 007 708(-2)	91	-3.118 902 096 172(-3)	137	-4.831 496 808 028(-4)
46	-1.529 272 982 383(-2)	92	-3.027 421 281 680(-3)		

Table 7

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3p_{1/2}$, obtained with $\alpha^{-1} = 137.035999139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	2.253 079 648 737(+5)	47	2.961 501 640 474(-2)	93	-5.821 665 076 994(-4)
2	1.407 454 544 846(+4)	48	2.660 256 095 643(-2)	94	-6.134 954 630 563(-4)
3	2.777 786 384 569(+3)	49	2.391 571 609 084(-2)	95	-6.412 175 427 710(-4)
4	8.778 590 781 585(+2)	50	2.151 495 639 188(-2)	96	-6.656 114 912 087(-4)
5	3.590 183 626 425(+2)	51	1.936 614 686 446(-2)	97	-6.869 336 974 364(-4)
6	1.728 120 707 372(+2)	52	1.743 972 583 622(-2)	98	-7.054 201 043 586(-4)
7	9.307 202 556 408(+1)	53	1.571 002 397 351(-2)	99	-7.212 879 385 637(-4)
8	5.441 676 605 826(+1)	54	1.415 469 474 468(-2)	100	-7.347 372 789 149(-4)
9	3.387 288 715 058(+1)	55	1.275 423 648 472(-2)	101	-7.459 524 799 211(-4)
10	2.215 129 173 089(+1)	56	1.149 159 002 773(-2)	102	-7.551 034 641 605(-4)
11	1.507 478 827 498(+1)	57	1.035 179 890 189(-2)	103	-7.623 468 964 634(-4)
12	1.060 143 677 914(+1)	58	9.321 721 496 853(-3)	104	-7.678 272 511 731(-4)
13	7.663 506 103 714(+0)	59	8.389 786 548 922(-3)	105	-7.716 777 825 625(-4)
14	5.670 768 326 413(+0)	60	7.545 784 844 853(-3)	106	-7.740 214 073 819(-4)
15	4.281 366 400 764(+0)	61	6.780 691 301 789(-3)	107	-7.749 715 075 145(-4)
16	3.289 268 464 602(+0)	62	6.086 512 598 482(-3)	108	-7.746 326 598 248(-4)
17	2.565 971 603 606(+0)	63	5.456 156 360 839(-3)	109	-7.731 012 994 635(-4)
18	2.028 897 544 840(+0)	64	4.883 318 580 250(-3)	110	-7.704 663 221 488(-4)
19	1.623 567 553 290(+0)	65	4.362 386 496 197(-3)	111	-7.668 096 302 449(-4)
20	1.313 194 222 044(+0)	66	3.888 354 628 892(-3)	112	-7.622 066 267 991(-4)
21	1.072 414 887 772(+0)	67	3.456 752 021 987(-3)	113	-7.567 266 610 665(-4)
22	8.834 142 382 734(-1)	68	3.063 579 064 713(-3)	114	-7.504 334 284 149(-4)
23	7.334 657 878 250(-1)	69	2.705 252 519 197(-3)	115	-7.433 853 268 585(-4)
24	6.133 382 373 914(-1)	70	2.378 557 591 857(-3)	116	-7.356 357 717 702(-4)
25	5.162 415 989 039(-1)	71	2.080 606 065 368(-3)	117	-7.272 334 695 573(-4)
26	4.371 174 602 330(-1)	72	1.808 799 656 204(-3)	118	-7.182 226 501 780(-4)
27	3.721 529 868 818(-1)	73	1.560 797 887 120(-3)	119	-7.086 432 572 860(-4)
28	3.184 430 030 589(-1)	74	1.334 489 868 466(-3)	120	-6.985 310 933 961(-4)
29	2.737 517 008 702(-1)	75	1.127 969 470 206(-3)	121	-6.879 179 156 326(-4)
30	2.363 424 023 942(-1)	76	9.395 134 407 774(-4)	122	-6.768 314 751 256(-4)
31	2.048 544 626 550(-1)	77	7.675 620 917 952(-4)	123	-6.652 954 896 115(-4)
32	1.782 132 551 088(-1)	78	6.107 022 208 586(-4)	124	-6.533 295 337 156(-4)
33	1.555 636 565 334(-1)	79	4.676 519 900 050(-4)	125	-6.409 488 238 433(-4)
34	1.362 204 137 883(-1)	80	3.372 475 159 160(-4)	126	-6.281 638 630 345(-4)
35	1.196 307 672 315(-1)	81	2.184 309 608 788(-4)	127	-6.149 798 928 825(-4)
36	1.053 460 613 117(-1)	82	1.102 399 416 397(-4)	128	-6.013 960 698 459(-4)
37	9.300 000 655 504(-2)	83	1.179 809 739 097(-5)	129	-5.874 042 329 500(-4)
38	8.229 190 749 879(-2)	84	-7.769 332 117 906(-5)	130	-5.729 870 412 697(-4)
39	7.297 362 892 179(-2)	85	-1.589 629 620 510(-4)	131	-5.581 150 963 677(-4)
40	6.483 939 821 434(-2)	86	-2.326 760 862 022(-4)	132	-5.427 423 489 936(-4)
41	5.771 777 535 698(-2)	87	-2.994 405 778 162(-4)	133	-5.267 984 479 616(-4)
42	5.146 529 116 126(-2)	88	-3.598 123 306 543(-4)	134	-5.101 753 606 939(-4)
43	4.596 137 798 548(-2)	89	-4.143 000 809 618(-4)	135	-4.927 033 391 057(-4)
44	4.110 430 810 152(-2)	90	-4.633 697 486 914(-4)	136	-4.741 197 416 352(-4)
45	3.680 792 236 720(-2)	91	-5.074 483 413 545(-4)	137	-4.553 361 480 661(-4)
46	3.299 898 227 783(-2)	92	-5.469 274 683 186(-4)		

Table 8

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3p_{3/2}$ ($\mu = \pm 1/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-2.253 619 636 543(+5)	47	-5.283 002 601 438(-2)	93	-4.382 984 551 435(-3)
2	-1.408 804 422 899(+4)	48	-4.880 910 212 206(-2)	94	-4.217 586 852 505(-3)
3	-2.783 785 165 072(+3)	49	-4.517 485 297 588(-2)	95	-4.059 881 012 262(-3)
4	-8.812 328 586 296(+2)	50	-4.188 291 569 502(-2)	96	-3.909 413 039 128(-3)
5	-3.611 771 430 726(+2)	51	-3.889 478 733 899(-2)	97	-3.765 759 884 777(-3)
6	-1.743 108 511 171(+2)	52	-3.617 695 415 994(-2)	98	-3.628 526 974 695(-3)
7	-9.417 284 670 092(+1)	53	-3.370 016 398 695(-2)	99	-3.497 345 952 933(-3)
8	-5.525 929 631 019(+1)	54	-3.143 881 604 543(-2)	100	-3.371 872 619 588(-3)
9	-3.453 833 399 136(+1)	55	-2.937 044 750 287(-2)	101	-3.251 785 041 677(-3)
10	-2.269 007 181 791(+1)	56	-2.747 529 998 186(-2)	102	-3.136 781 820 031(-3)
11	-1.551 984 925 732(+1)	57	-2.573 595 242 306(-2)	103	-3.026 580 496 432(-3)
12	-1.097 521 666 397(+1)	58	-2.413 700 919 040(-2)	104	-2.920 916 086 707(-3)
13	-7.981 812 500 582(+0)	59	-2.266 483 432 400(-2)	105	-2.819 539 726 672(-3)
14	-5.945 058 175 495(+0)	60	-2.130 732 446 792(-2)	106	-2.722 217 418 896(-3)
15	-4.520 145 911 594(+0)	61	-2.005 371 431 041(-2)	107	-2.628 728 869 054(-3)
16	-3.498 985 331 674(+0)	62	-1.889 440 943 867(-2)	108	-2.538 866 401 341(-3)
17	-2.751 602 028 338(+0)	63	-1.782 084 237 633(-2)	109	-2.452 433 942 839(-3)
18	-2.194 343 262 026(+0)	64	-1.682 534 828 021(-2)	110	-2.369 246 067 020(-3)
19	-1.771 930 918 400(+0)	65	-1.590 105 735 359(-2)	111	-2.289 127 086 553(-3)
20	-1.446 972 916 787(+0)	66	-1.504 180 151 118(-2)	112	-2.211 910 185 318(-3)
21	-1.193 642 369 298(+0)	67	-1.424 203 322 520(-2)	113	-2.137 436 578 922(-3)
22	-9.937 627 852 646(-1)	68	-1.349 675 480 860(-2)	114	-2.065 554 691 917(-3)
23	-8.343 232 689 235(-1)	69	-1.280 145 666 232(-2)	115	-1.996 119 338 262(-3)
24	-7.058 661 000 903(-1)	70	-1.215 206 323 948(-2)	116	-1.928 990 889 064(-3)
25	-6.014 192 279 083(-1)	71	-1.154 488 566 765(-2)	117	-1.864 034 408 017(-3)
26	-5.157 765 018 528(-1)	72	-1.097 658 012 822(-2)	118	-1.801 118 729 662(-3)
27	-4.450 041 909 658(-1)	73	-1.044 411 122 443(-2)	119	-1.740 115 447 942(-3)
28	-3.860 974 185 415(-1)	74	-9.944 719 681 017(-3)	120	-1.680 897 771 276(-3)
29	-3.367 375 635 824(-1)	75	-9.475 893 812 523(-3)	121	-1.623 339 183 709(-3)
30	-2.951 187 029 957(-1)	76	-9.035 344 276 842(-3)	122	-1.567 311 826 495(-3)
31	-2.598 219 318 800(-1)	77	-8.620 981 698 059(-3)	123	-1.512 684 475 701(-3)
32	-2.297 233 222 014(-1)	78	-8.230 896 799 857(-3)	124	-1.459 319 930 243(-3)
33	-2.039 258 041 026(-1)	79	-7.863 342 739 572(-3)	125	-1.407 071 525 691(-3)
34	-1.817 082 542 449(-1)	80	-7.516 719 374 597(-3)	126	-1.355 778 323 459(-3)
35	-1.624 870 927 398(-1)	81	-7.189 559 228 432(-3)	127	-1.305 258 237 710(-3)
36	-1.457 870 640 073(-1)	82	-6.880 514 954 158(-3)	128	-1.255 297 842 467(-3)
37	-1.312 188 238 309(-1)	83	-6.588 348 119 300(-3)	129	-1.205 636 612 851(-3)
38	-1.184 616 150 147(-1)	84	-6.311 919 158 563(-3)	130	-1.155 941 357 871(-3)
39	-1.072 497 791 613(-1)	85	-6.050 178 360 340(-3)	131	-1.105 762 264 352(-3)
40	-9.736 218 310 255(-2)	86	-5.802 157 769 625(-3)	132	-1.054 451 640 406(-3)
41	-8.861 387 632 359(-2)	87	-5.566 963 904 484(-3)	133	-1.000 998 727 871(-3)
42	-8.084 946 810 726(-2)	88	-5.343 771 195 769(-3)	134	-9.436 464 304 010(-4)
43	-7.393 783 915 312(-2)	89	-5.131 816 070 673(-3)	135	-8.788 040 064 270(-4)
44	-6.776 789 529 949(-2)	90	-4.930 391 610 179(-3)	136	-7.966 180 491 771(-4)
45	-6.224 513 994 779(-2)	91	-4.738 842 718 716(-3)	137	-6.139 274 383 931(-4)
46	-5.728 889 337 946(-2)	92	-4.556 561 751 516(-3)		

Table 9

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3p_{3/2}$ ($\mu = \pm 3/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-3.599 951 541 316(+1)	47	-1.581 344 317 096(-2)	93	-3.681 907 779 187(-3)
2	-8.999 515 414 600(+0)	48	-1.514 152 196 291(-2)	94	-3.593 908 592 141(-3)
3	-3.999 515 417 007(+0)	49	-1.451 032 127 476(-2)	95	-3.508 677 457 715(-3)
4	-2.249 515 420 376(+0)	50	-1.391 661 634 388(-2)	96	-3.426 099 682 411(-3)
5	-1.439 515 424 709(+0)	51	-1.335 749 542 934(-2)	97	-3.346 066 454 083(-3)
6	-9.995 154 300 037(-1)	52	-1.283 032 404 604(-2)	98	-3.268 474 483 707(-3)
7	-7.342 093 138 125(-1)	53	-1.233 271 387 727(-2)	99	-3.193 225 672 345(-3)
8	-5.620 154 434 822(-1)	54	-1.186 249 567 930(-2)	100	-3.120 226 801 306(-3)
9	-4.439 598 961 100(-1)	55	-1.141 769 560 251(-2)	101	-3.049 389 243 671(-3)
10	-3.595 154 608 118(-1)	56	-1.099 651 444 560(-2)	102	-2.980 628 695 521(-3)
11	-2.970 361 320 778(-1)	57	-1.059 730 943 482(-2)	103	-2.913 864 925 341(-3)
12	-2.495 154 819 926(-1)	58	-1.021 857 818 298(-2)	104	-2.849 021 540 206(-3)
13	-2.125 332 455 065(-1)	59	-9.858 944 535 296(-3)	105	-2.786 025 767 482(-3)
14	-1.831 889 764 125(-1)	60	-9.517 146 052 552(-3)	106	-2.724 808 250 876(-3)
15	-1.595 155 209 851(-1)	61	-9.192 022 918 728(-3)	107	-2.665 302 859 760(-3)
16	-1.401 405 359 083(-1)	62	-8.882 508 090 695(-3)	108	-2.607 446 510 804(-3)
17	-1.240 830 258 428(-1)	63	-8.587 618 533 612(-3)	109	-2.551 179 001 003(-3)
18	-1.106 266 797 544(-1)	64	-8.306 447 407 350(-3)	110	-2.496 442 851 286(-3)
19	-9.923 857 814 497(-2)	65	-8.038 157 087 817(-3)	111	-2.443 183 159 938(-3)
20	-8.951 560 523 006(-2)	66	-7.781 972 922 763(-3)	112	-2.391 347 465 147(-3)
21	-8.114 827 802 908(-2)	67	-7.537 177 635 034(-3)	113	-2.340 885 616 025(-3)
22	-7.389 581 095 789(-2)	68	-7.303 106 297 671(-3)	114	-2.291 749 651 510(-3)
23	-6.756 859 738 911(-2)	69	-7.079 141 815 033(-3)	115	-2.243 893 686 616(-3)
24	-6.201 568 995 919(-2)	70	-6.864 710 852 549(-3)	116	-2.197 273 805 507(-3)
25	-5.711 571 354 902(-2)	71	-6.659 280 164 896(-3)	117	-2.151 847 960 948(-3)
26	-5.277 017 597 173(-2)	72	-6.462 353 278 650(-3)	118	-2.107 575 879 694(-3)
27	-4.889 847 966 727(-2)	73	-6.273 467 490 837(-3)	119	-2.064 418 973 414(-3)
28	-4.543 415 744 391(-2)	74	-6.092 191 149 461(-3)	120	-2.022 340 254 799(-3)
29	-4.232 200 065 452(-2)	75	-5.918 121 186 140(-3)	121	-1.981 304 258 498(-3)
30	-3.951 584 594 454(-2)	76	-5.750 880 874 483(-3)	122	-1.941 276 966 567(-3)
31	-3.697 685 346 084(-2)	77	-5.590 117 790 918(-3)	123	-1.902 225 738 155(-3)
32	-3.467 215 564 481(-2)	78	-5.435 501 957 331(-3)	124	-1.864 119 243 131(-3)
33	-3.257 378 817 943(-2)	79	-5.286 724 147 230(-3)	125	-1.826 927 399 420(-3)
34	-3.065 783 771 005(-2)	80	-5.143 494 339 187(-3)	126	-1.790 621 313 804(-3)
35	-2.890 375 752 143(-2)	81	-5.005 540 303 093(-3)	127	-1.755 173 225 972(-3)
36	-2.729 381 438 190(-2)	82	-4.872 606 306 358(-3)	128	-1.720 556 455 618(-3)
37	-2.581 263 858 925(-2)	83	-4.744 451 928 563(-3)	129	-1.686 745 352 401(-3)
38	-2.444 685 578 593(-2)	84	-4.620 850 974 296(-3)	130	-1.653 715 248 583(-3)
39	-2.318 478 399 143(-2)	85	-4.501 590 474 984(-3)	131	-1.621 442 414 196(-3)
40	-2.201 618 297 622(-2)	86	-4.386 469 771 504(-3)	132	-1.589 904 014 568(-3)
41	-2.093 204 589 197(-2)	87	-4.275 299 670 162(-3)	133	-1.559 078 070 083(-3)
42	-1.992 442 520 773(-2)	88	-4.167 901 665 443(-3)	134	-1.528 943 418 030(-3)
43	-1.898 628 664 563(-2)	89	-4.064 107 223 530(-3)	135	-1.499 479 676 428(-3)
44	-1.811 138 608 454(-2)	90	-3.963 757 121 251(-3)	136	-1.470 667 209 701(-3)
45	-1.729 416 539 503(-2)	91	-3.866 700 835 581(-3)	137	-1.442 487 096 101(-3)
46	-1.652 966 394 988(-2)	92	-3.772 795 979 350(-3)		

Table 10

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3d_{3/2}$ ($\mu = \pm 1/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	7.300 965 637 634(+5)	47	1.382 152 566 398(−1)	93	7.014 861 885 531(−3)
2	4.562 621 482 550(+4)	48	1.266 106 404 598(−1)	94	6.668 966 264 598(−3)
3	9.010 998 791 784(+3)	49	1.161 726 868 210(−1)	95	6.342 269 233 241(−3)
4	2.850 433 485 628(+3)	50	1.067 644 863 689(−1)	96	6.033 549 850 614(−3)
5	1.167 167 467 288(+3)	51	9.826 745 342 003(−2)	97	5.741 675 544 197(−3)
6	5.626 520 147 653(+2)	52	9.057 858 044 552(−2)	98	5.465 594 924 698(−3)
7	3.035 664 451 768(+2)	53	8.360 814 639 921(−2)	99	5.204 331 249 137(−3)
8	1.778 510 190 602(+2)	54	7.727 779 708 599(−2)	100	4.956 976 467 939(−3)
9	1.109 649 855 296(+2)	55	7.151 893 169 168(−2)	101	4.722 685 798 743(−3)
10	7.275 535 696 625(+1)	56	6.627 134 219 887(−2)	102	4.500 672 775 791(−3)
11	4.965 608 395 653(+1)	57	6.148 206 243 195(−2)	103	4.290 204 729 127(−3)
12	3.503 205 992 112(+1)	58	5.710 439 147 319(−2)	104	4.090 598 652 646(−3)
13	2.541 170 970 698(+1)	59	5.309 706 260 397(−2)	105	3.901 217 424 267(−3)
14	1.887 473 795 509(+1)	60	4.942 353 408 648(−2)	106	3.721 466 345 294(−3)
15	1.430 813 127 641(+1)	61	4.605 138 227 148(−2)	107	3.550 789 969 362(−3)
16	1.104 058 164 226(+1)	62	4.295 178 089 985(−2)	108	3.388 669 194 380(−3)
17	8.653 048 412 936(+0)	63	4.009 905 321 835(−2)	109	3.234 618 593 494(−3)
18	6.876 012 904 102(+0)	64	3.747 028 577 856(−2)	110	3.088 183 963 528(−3)
19	5.531 502 038 377(+0)	65	3.504 499 463 042(−2)	111	2.948 940 071 428(−3)
20	4.499 218 736 289(+0)	66	3.280 483 613 677(−2)	112	2.816 488 581 157(−3)
21	3.696 138 953 551(+0)	67	3.073 335 588 449(−2)	113	2.690 456 145 175(−3)
22	3.063 880 523 391(+0)	68	2.881 577 020 174(−2)	114	2.570 492 646 153(−3)
23	2.560 689 477 752(+0)	69	2.703 877 564 806(−2)	115	2.456 269 575 945(−3)
24	2.156 242 308 687(+0)	70	2.539 038 255 788(−2)	116	2.347 478 540 039(−3)
25	1.828 206 482 298(+0)	71	2.385 976 931 323(−2)	117	2.243 829 876 846(−3)
26	1.559 922 546 230(+0)	72	2.243 715 451 954(−2)	118	2.145 051 382 123(−3)
27	1.338 815 810 581(+0)	73	2.111 368 467 647(−2)	119	2.050 887 129 763(−3)
28	1.155 291 163 955(+0)	74	1.988 133 528 657(−2)	120	1.961 096 380 949(−3)
29	1.001 953 132 875(+0)	75	1.873 282 364 148(−2)	121	1.875 452 574 425(−3)
30	8.730 482 392 226(−1)	76	1.766 153 177 485(−2)	122	1.793 742 391 259(−3)
31	7.640 614 424 179(−1)	77	1.666 143 828 387(−2)	123	1.715 764 888 084(−3)
32	6.714 207 855 885(−1)	78	1.572 705 790 080(−2)	124	1.641 330 693 342(−3)
33	5.922 789 538 408(−1)	79	1.485 338 784 915(−2)	125	1.570 261 261 539(−3)
34	5.243 501 244 773(−1)	80	1.403 586 014 978(−2)	126	1.502 388 180 971(−3)
35	4.657 869 895 405(−1)	81	1.327 029 915 343(−2)	127	1.437 552 530 798(−3)
36	4.150 872 566 405(−1)	82	1.255 288 367 207(−2)	128	1.375 604 283 784(−3)
37	3.710 219 834 171(−1)	83	1.188 011 316 300(−2)	129	1.316 401 751 378(−3)
38	3.325 802 259 926(−1)	84	1.124 877 749 015(−2)	130	1.259 811 068 366(−3)
39	2.989 259 784 155(−1)	85	1.065 592 984 775(−2)	131	1.205 705 714 951(−3)
40	2.693 644 447 883(−1)	86	1.009 886 248 361(−2)	132	1.153 966 075 355(−3)
41	2.433 154 503 706(−1)	87	9.575 084 904 592(−3)	133	1.104 479 034 847(−3)
42	2.202 923 519 639(−1)	88	9.082 304 285 923(−3)	134	1.057 137 625 440(−3)
43	1.998 852 127 268(−1)	89	8.618 407 839 891(−3)	135	1.011 840 763 111(−3)
44	1.817 473 047 893(−1)	90	8.181 446 928 965(−3)	136	9.684 933 165 501(−4)
45	1.655 842 243 911(−1)	91	7.769 622 733 997(−3)	137	9.270 118 604 514(−4)
46	1.511 450 697 722(−1)	92	7.381 273 310 506(−3)		

Table 11

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3d_{3/2}$ ($\mu = \pm 3/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	4.867 170 427 249(+5)	47	8.602 099 797 280(−2)	93	3.270 743 993 589(−3)
2	3.041 397 676 633(+4)	48	7.854 587 339 729(−2)	94	3.074 334 771 839(−3)
3	6.005 777 188 294(+3)	49	7.183 268 773 333(−2)	95	2.889 647 729 010(−3)
4	1.899 414 206 410(+3)	50	6.579 142 215 135(−2)	96	2.715 913 505 579(−3)
5	7.775 518 608 467(+2)	51	6.034 415 187 203(−2)	97	2.552 419 366 998(−3)
6	3.747 126 702 718(+2)	52	5.542 322 973 071(−2)	98	2.398 504 552 941(−3)
7	2.020 921 318 113(+2)	53	5.096 977 048 562(−2)	99	2.253 556 048 873(−3)
8	1.183 488 120 139(+2)	54	4.693 238 160 067(−2)	100	2.117 004 737 932(−3)
9	7.380 403 348 125(+1)	55	4.326 609 680 709(−2)	101	1.988 321 895 654(−3)
10	4.836 378 727 173(+1)	56	3.993 147 711 516(−2)	102	1.867 015 994 085(−3)
11	3.298 856 944 505(+1)	57	3.689 385 059 673(−2)	103	1.752 629 785 362(−3)
12	2.325 770 033 699(+1)	58	3.412 266 756 745(−2)	104	1.644 737 638 004(−3)
13	1.685 851 550 415(+1)	59	3.159 095 205 196(−2)	105	1.542 943 101 917(−3)
14	1.251 194 599 180(+1)	60	2.927 483 383 938(−2)	106	1.446 876 680 612(−3)
15	9.476 747 878 165(+0)	61	2.715 314 820 217(−2)	107	1.356 193 791 312(−3)
16	7.305 916 166 512(+0)	62	2.520 709 259 449(−2)	108	1.270 572 895 610(−3)
17	5.720 471 928 567(+0)	63	2.341 993 147 119(−2)	109	1.189 713 785 035(−3)
18	4.541 014 606 832(+0)	64	2.177 674 185 902(−2)	110	1.113 336 007 491(−3)
19	3.649 102 729 529(+0)	65	2.026 419 353 296(−2)	111	1.041 177 421 878(−3)
20	2.964 695 010 925(+0)	66	1.887 035 865 415(−2)	112	9.729 928 694 670(−4)
21	2.432 562 442 655(+0)	67	1.758 454 655 389(−2)	113	9.085 529 516 967(−4)
22	2.013 877 219 041(+0)	68	1.639 716 003 255(−2)	114	8.476 429 050 609(−4)
23	1.680 877 097 290(+0)	69	1.529 957 011 035(−2)	115	7.900 615 646 396(−4)
24	1.413 405 107 189(+0)	70	1.428 400 663 920(−2)	116	7.356 204 086 288(−4)
25	1.196 620 094 241(+0)	71	1.334 346 257 912(−2)	117	6.841 426 769 363(−4)
26	1.019 454 059 393(+0)	72	1.247 161 007 222(−2)	118	6.354 625 575 598(−4)
27	8.735 552 195 380(−1)	73	1.166 272 672 374(−2)	119	5.894 244 350 404(−4)
28	7.525 526 820 974(−1)	74	1.091 163 073 215(−2)	120	5.458 821 958 062(−4)
29	6.515 376 014 502(−1)	75	1.021 362 370 608(−2)	121	5.046 985 856 936(−4)
30	5.666 922 779 316(−1)	76	9.564 440 171 373(−3)	122	4.657 446 153 561(−4)
31	4.950 217 888 754(−1)	77	8.960 202 911 774(−3)	123	4.288 990 096 540(−4)
32	4.341 576 115 282(−1)	78	8.397 383 405 591(−3)	124	3.940 476 974 653(−4)
33	3.822 124 109 723(−1)	79	7.872 766 721 871(−3)	125	3.610 833 386 704(−4)
34	3.376 716 050 471(−1)	80	7.383 420 325 875(−3)	126	3.299 048 853 472(−4)
35	2.993 116 455 029(−1)	81	6.926 666 317 264(−3)	127	3.004 171 744 690(−4)
36	2.661 379 003 360(−1)	82	6.500 056 687 449(−3)	128	2.725 305 496 322(−4)
37	2.373 370 517 456(−1)	83	6.101 351 236 618(−3)	129	2.461 605 095 486(−4)
38	2.122 403 382 851(−1)	84	5.728 497 837 415(−3)	130	2.212 273 812 330(−4)
39	1.902 949 656 452(−1)	85	5.379 614 772 207(−3)	131	1.976 560 159 868(−4)
40	1.710 417 188 720(−1)	86	5.052 974 905 373(−3)	132	1.753 755 064 402(−4)
41	1.540 973 174 679(−1)	87	4.746 991 481 851(−3)	133	1.543 189 230 566(−4)
42	1.391 404 233 396(−1)	88	4.460 205 368 939(−3)	134	1.344 230 686 367(−4)
43	1.259 004 808 115(−1)	89	4.191 273 580 723(−3)	135	1.156 282 494 772(−4)
44	1.141 487 662 390(−1)	90	3.938 958 943 899(−3)	136	9.787 806 195 005(−5)
45	1.036 911 719 427(−1)	91	3.702 120 780 660(−3)	137	8.111 919 336 523(−5)
46	9.436 235 921 464(−2)	92	3.479 706 498 989(−3)		

Table 12

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3d_{5/2}$ ($\mu = \pm 1/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-7.301 295 633 993(+5)	47	-1.527 906 889 615(-1)	93	-1.046 863 644 964(-2)
2	-4.563 446 446 141(+4)	48	-1.405 701 300 375(-1)	94	-1.004 204 115 620(-2)
3	-9.014 665 094 365(+3)	49	-1.295 535 604 542(-1)	95	-9.637 181 328 664(-3)
4	-2.852 495 621 544(+3)	50	-1.196 011 148 224(-1)	96	-9.252 730 884 592(-3)
5	-1.168 487 103 207(+3)	51	-1.105 915 383 609(-1)	97	-8.887 457 500 952(-3)
6	-5.635 683 173 539(+2)	52	-1.024 194 085 943(-1)	98	-8.540 215 100 647(-3)
7	-3.042 395 504 902(+2)	53	-9.499 281 518 380(-2)	99	-8.209 937 010 306(-3)
8	-1.783 662 799 902(+2)	54	-8.823 141 545 890(-2)	100	-7.895 629 723 348(-3)
9	-1.113 720 288 720(+2)	55	-8.206 479 924 105(-2)	101	-7.596 367 209 358(-3)
10	-7.308 499 290 675(+1)	56	-7.643 110 924 276(-2)	102	-7.311 285 717 086(-3)
11	-4.992 844 717 585(+1)	57	-7.127 587 341 018(-2)	103	-7.039 579 023 927(-3)
12	-3.526 086 254 104(+1)	58	-6.655 101 363 495(-2)	104	-6.780 494 089 633(-3)
13	-2.560 661 193 968(+1)	59	-6.221 400 172 083(-2)	105	-6.533 327 076 369(-3)
14	-1.904 274 127 036(+1)	60	-5.822 713 869 159(-2)	106	-6.297 419 701 108(-3)
15	-1.445 443 391 981(+1)	61	-5.455 693 773 077(-2)	107	-6.072 155 889 783(-3)
16	-1.116 912 387 797(+1)	62	-5.117 359 445 379(-2)	108	-5.856 958 705 706(-3)
17	-8.766 871 259 421(+0)	63	-4.805 053 098 946(-2)	109	-5.651 287 527 467(-3)
18	-6.977 500 761 360(+0)	64	-4.516 400 261 652(-2)	110	-5.454 635 453 992(-3)
19	-5.622 550 796 875(+0)	65	-4.249 275 756 005(-2)	111	-5.266 526 916 613(-3)
20	-4.581 354 763 687(+0)	66	-4.001 774 208 212(-2)	112	-5.086 515 479 939(-3)
21	-3.770 604 924 779(+0)	67	-3.772 184 426 261(-2)	113	-4.914 181 815 081(-3)
22	-3.131 698 393 258(+0)	68	-3.558 967 091 031(-2)	114	-4.749 131 830 333(-3)
23	-2.622 707 394 993(+0)	69	-3.360 735 291 068(-2)	115	-4.590 994 945 836(-3)
24	-2.213 170 053 618(+0)	70	-3.176 237 503 831(-2)	116	-4.439 422 499 982(-3)
25	-1.880 642 574 707(+0)	71	-3.004 342 686 379(-2)	117	-4.294 086 276 479(-3)
26	-1.608 375 221 403(+0)	72	-2.844 027 188 862(-2)	118	-4.154 677 141 989(-3)
27	-1.383 719 422 704(+0)	73	-2.694 363 246 467(-2)	119	-4.020 903 785 201(-3)
28	-1.197 019 138 954(+0)	74	-2.554 508 841 005(-2)	120	-3.892 491 548 994(-3)
29	-1.040 828 288 750(+0)	75	-2.423 698 753 349(-2)	121	-3.769 181 348 118(-3)
30	-9.093 510 775 626(-1)	76	-2.301 236 653 250(-2)	122	-3.650 728 665 479(-3)
31	-7.980 368 616 128(-1)	77	-2.186 488 094 560(-2)	123	-3.536 902 620 742(-3)
32	-7.032 835 554 317(-1)	78	-2.078 874 302 131(-2)	124	-3.427 485 105 480(-3)
33	-6.222 182 101 673(-1)	79	-1.977 866 652 164(-2)	125	-3.322 269 979 655(-3)
34	-5.525 330 825 458(-1)	80	-1.882 981 761 046(-2)	126	-3.221 062 324 594(-3)
35	-4.923 620 301 194(-1)	81	-1.793 777 109 019(-2)	127	-3.123 677 748 114(-3)
36	-4.401 865 050 347(-1)	82	-1.709 847 134 706(-2)	128	-3.029 941 737 748(-3)
37	-3.947 634 760 365(-1)	83	-1.630 819 744 870(-2)	129	-2.939 689 058 414(-3)
38	-3.550 697 394 179(-1)	84	-1.556 353 190 887(-2)	130	-2.852 763 191 148(-3)
39	-3.202 585 807 440(-1)	85	-1.486 133 269 611(-2)	131	-2.769 015 809 816(-3)
40	-2.896 258 172 386(-1)	86	-1.419 870 811 609(-2)	132	-2.688 306 292 963(-3)
41	-2.625 830 178 824(-1)	87	-1.357 299 424 342(-2)	133	-2.610 501 268 195(-3)
42	-2.386 362 542 385(-1)	88	-1.298 173 461 843(-2)	134	-2.535 474 186 705(-3)
43	-2.173 691 413 760(-1)	89	-1.242 266 195 914(-2)	135	-2.463 104 925 729(-3)
44	-1.984 292 276 456(-1)	90	-1.189 368 166 837(-2)	136	-2.393 279 416 921(-3)
45	-1.815 170 143 332(-1)	91	-1.139 285 694 233(-2)	137	-2.325 889 298 771(-3)
46	-1.663 770 524 355(-1)	92	-1.091 839 530 964(-2)		

Table 13

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3d_{5/2}$ ($\mu = \pm 3/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-4.867 620 421 635(+5)	47	-1.058 323 534 299(-1)	93	-7.918 361 781 247(-3)
2	-3.042 522 620 491(+4)	48	-9.751 733 756 547(-2)	94	-7.611 972 956 068(-3)
3	-6.010 776 626 879(+3)	49	-9.001 516 147 331(-2)	95	-7.320 766 554 808(-3)
4	-1.902 226 145 000(+3)	50	-8.323 177 537 031(-2)	96	-7.043 829 849 743(-3)
5	-7.793 512 994 430(+2)	51	-7.708 561 480 069(-2)	97	-6.780 314 089 776(-3)
6	-3.759 621 088 759(+2)	52	-7.150 573 949 303(-2)	98	-6.529 429 401 888(-3)
7	-2.030 099 377 716(+2)	53	-6.643 027 880 940(-2)	99	-6.290 440 146 415(-3)
8	-1.190 513 756 379(+2)	54	-6.180 512 865 865(-2)	100	-6.062 660 681 625(-3)
9	-7.435 902 767 291(+1)	55	-5.758 285 545 965(-2)	101	-5.845 451 497 854(-3)
10	-4.881 322 592 132(+1)	56	-5.372 177 122 068(-2)	102	-5.638 215 685 643(-3)
11	-3.335 990 893 601(+1)	57	-5.018 515 054 602(-2)	103	-5.440 395 706 081(-3)
12	-2.356 963 901 784(+1)	58	-4.694 056 576 690(-2)	104	-5.251 470 434 821(-3)
13	-1.712 422 639 210(+1)	59	-4.395 932 071 410(-2)	105	-5.070 952 454 210(-3)
14	-1.274 097 654 632(+1)	60	-4.121 596 712 729(-2)	106	-4.898 385 570 570(-3)
15	-9.676 186 616 540(+0)	61	-3.868 789 050 846(-2)	107	-4.733 342 535 959(-3)
16	-7.481 136 176 902(+0)	62	-3.635 495 450 741(-2)	108	-4.575 422 955 862(-3)
17	-5.875 620 054 953(+0)	63	-3.419 919 478 496(-2)	109	-4.424 251 366 043(-3)
18	-4.679 342 304 402(+0)	64	-3.220 455 481 723(-2)	110	-4.279 475 463 494(-3)
19	-3.773 195 304 098(+0)	65	-3.035 665 734 857(-2)	111	-4.140 764 477 830(-3)
20	-3.076 633 873 577(+0)	66	-2.864 260 622 431(-2)	112	-4.007 807 670 844(-3)
21	-2.534 042 150 749(+0)	67	-2.705 081 417 875(-2)	113	-3.880 312 953 076(-3)
22	-2.106 291 347 955(+0)	68	-2.557 085 285 304(-2)	114	-3.758 005 607 333(-3)
23	-1.765 382 214 118(+0)	69	-2.419 332 189 726(-2)	115	-3.640 627 110 021(-3)
24	-1.490 969 094 821(+0)	70	-2.290 973 449 453(-2)	116	-3.527 934 042 019(-3)
25	-1.268 059 116 666(+0)	71	-2.171 241 704 762(-2)	117	-3.419 697 081 585(-3)
26	-1.085 461 165 369(+0)	72	-2.059 442 110 622(-2)	118	-3.315 700 072 465(-3)
27	-9.347 227 108 708(-1)	73	-1.954 944 589 623(-2)	119	-3.215 739 161 004(-3)
28	-8.093 897 766 039(-1)	74	-1.857 177 005 044(-2)	120	-3.119 621 996 614(-3)
29	-7.044 845 061 380(-1)	75	-1.765 619 134 132(-2)	121	-3.027 166 990 465(-3)
30	-6.161 314 956 150(-1)	76	-1.679 797 338 603(-2)	122	-2.938 202 627 708(-3)
31	-5.412 872 725 522(-1)	77	-1.599 279 843 812(-2)	123	-2.852 566 828 956(-3)
32	-4.775 422 297 476(-1)	78	-1.523 672 550 248(-2)	124	-2.770 106 357 134(-3)
33	-4.229 740 768 873(-1)	79	-1.452 615 311 429(-2)	125	-2.690 676 266 125(-3)
34	-3.760 383 401 171(-1)	80	-1.385 778 621 122(-2)	126	-2.614 139 387 965(-3)
35	-3.354 857 877 930(-1)	81	-1.322 860 660 446(-2)	127	-2.540 365 855 597(-3)
36	-3.002 996 213 716(-1)	82	-1.263 584 661 884(-2)	128	-2.469 232 658 469(-3)
37	-2.696 473 109 242(-1)	83	-1.207 696 552 813(-2)	129	-2.400 623 228 467(-3)
38	-2.428 433 770 570(-1)	84	-1.154 962 845 981(-2)	130	-2.334 427 053 903(-3)
39	-2.193 204 229 849(-1)	85	-1.105 168 748 459(-2)	131	-2.270 539 319 440(-3)
40	-1.986 064 334 668(-1)	86	-1.058 116 464 198(-2)	132	-2.208 860 570 048(-3)
41	-1.803 068 694 444(-1)	87	-1.013 623 668 380(-2)	133	-2.149 296 397 197(-3)
42	-1.640 904 584 106(-1)	88	-9.715 221 344 419(-3)	134	-2.091 757 145 669(-3)
43	-1.496 778 518 423(-1)	89	-9.316 564 969 600(-3)	135	-2.036 157 639 485(-3)
44	-1.368 325 209 431(-1)	90	-8.938 831 355 972(-3)	136	-1.982 416 925 581(-3)
45	-1.253 534 103 716(-1)	91	-8.580 691 670 813(-3)	137	-1.930 458 033 936(-3)
46	-1.150 689 806 355(-1)	92	-8.240 915 336 976(-3)		

Table 14

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) of hydrogenlike atoms in the excited state $3d_{5/2}$ ($\mu = \pm 5/2$), obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014).

Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$	Z	$\chi[\alpha^2 a_0^3]$
1	-2.699 969 190 335(+1)	47	-1.191 568 236 683(-2)	93	-2.817 812 444 465(-3)
2	-6.749 691 904 782(+0)	48	-1.141 175 262 133(-2)	94	-2.751 836 555 806(-3)
3	-2.999 691 907 161(+0)	49	-1.093 836 351 152(-2)	95	-2.687 937 007 096(-3)
4	-1.687 191 910 493(+0)	50	-1.049 309 646 613(-2)	96	-2.626 027 780 046(-3)
5	-1.079 691 914 777(+0)	51	-1.007 376 768 019(-2)	97	-2.566 027 267 424(-3)
6	-7.496 919 200 131(-1)	52	-9.678 401 290 602(-3)	98	-2.507 858 004 372(-3)
7	-5.507 123 343 646(-1)	53	-9.305 206 060 602(-3)	99	-2.451 446 418 634(-3)
8	-4.215 669 333 417(-1)	54	-8.952 555 058 160(-3)	100	-2.396 722 598 180(-3)
9	-3.330 252 747 679(-1)	55	-8.618 967 896 857(-3)	101	-2.343 620 074 845(-3)
10	-2.696 919 504 799(-1)	56	-8.303 095 176 532(-3)	102	-2.292 075 622 759(-3)
11	-2.228 324 563 456(-1)	57	-8.003 704 817 696(-3)	103	-2.242 029 070 391(-3)
12	-1.871 919 714 286(-1)	58	-7.719 670 030 807(-3)	104	-2.193 423 125 196(-3)
13	-1.594 552 969 417(-1)	59	-7.449 958 700 643(-3)	105	-2.146 203 209 892(-3)
14	-1.374 470 982 299(-1)	60	-7.193 623 998 687(-3)	106	-2.100 317 309 493(-3)
15	-1.196 920 099 991(-1)	61	-6.949 796 063 827(-3)	107	-2.055 715 828 311(-3)
16	-1.051 607 747 627(-1)	62	-6.717 674 614 644(-3)	108	-2.012 351 456 172(-3)
17	-9.311 764 601 641(-2)	63	-6.496 522 375 957(-3)	109	-1.970 179 043 196(-3)
18	-8.302 539 048 471(-2)	64	-6.285 659 218 637(-3)	110	-1.929 155 482 498(-3)
19	-7.448 431 854 419(-2)	65	-6.084 456 925 604(-3)	111	-1.889 239 600 264(-3)
20	-6.719 209 335 684(-2)	66	-5.892 334 508 681(-3)	112	-1.850 392 052 653(-3)
21	-6.091 660 268 747(-2)	67	-5.708 754 011 037(-3)	113	-1.812 575 229 067(-3)
22	-5.547 725 734 824(-2)	68	-5.533 216 738 503(-3)	114	-1.775 753 161 335(-3)
23	-5.073 185 236 891(-2)	69	-5.365 259 870 427(-3)	115	-1.739 891 438 392(-3)
24	-4.656 717 722 711(-2)	70	-5.204 453 406 978(-3)	116	-1.704 957 126 092(-3)
25	-4.289 220 058 383(-2)	71	-5.050 397 415 285(-3)	117	-1.670 918 691 798(-3)
26	-3.963 305 329 925(-2)	72	-4.902 719 541 426(-3)	118	-1.637 745 933 418(-3)
27	-3.672 928 720 366(-2)	73	-4.761 072 759 338(-3)	119	-1.605 409 912 608(-3)
28	-3.413 105 190 364(-2)	74	-4.625 133 331 216(-3)	120	-1.573 882 891 852(-3)
29	-3.179 694 091 421(-2)	75	-4.494 598 956 989(-3)	121	-1.543 138 275 160(-3)
30	-2.969 233 171 984(-2)	76	-4.369 187 093 107(-3)	122	-1.513 150 552 167(-3)
31	-2.778 809 443 108(-2)	77	-4.248 633 423 154(-3)	123	-1.483 895 245 386(-3)
32	-2.605 957 837 939(-2)	78	-4.132 690 464 838(-3)	124	-1.455 348 860 441(-3)
33	-2.448 581 032 744(-2)	79	-4.021 126 299 608(-3)	125	-1.427 488 839 067(-3)
34	-2.304 885 525 969(-2)	80	-3.913 723 412 736(-3)	126	-1.400 293 514 708(-3)
35	-2.173 330 314 016(-2)	81	-3.810 277 633 011(-3)	127	-1.373 742 070 563(-3)
36	-2.052 585 404 558(-2)	82	-3.710 597 162 389(-3)	128	-1.347 814 499 910(-3)
37	-1.941 498 069 980(-2)	83	-3.614 501 686 982(-3)	129	-1.322 491 568 574(-3)
38	-1.839 065 233 514(-2)	84	-3.521 821 561 684(-3)	130	-1.297 754 779 412(-3)
39	-1.744 410 746 675(-2)	85	-3.432 397 061 550(-3)	131	-1.273 586 338 688(-3)
40	-1.656 766 592 302(-2)	86	-3.346 077 693 748(-3)	132	-1.249 969 124 220(-3)
41	-1.575 457 256 826(-2)	87	-3.262 721 564 551(-3)	133	-1.226 886 655 202(-3)
42	-1.499 886 675 483(-2)	88	-3.182 194 796 394(-3)	134	-1.204 323 063 596(-3)
43	-1.429 527 277 491(-2)	89	-3.104 370 990 521(-3)	135	-1.182 263 066 998(-3)
44	-1.363 910 753 824(-2)	90	-3.029 130 731 184(-3)	136	-1.160 691 942 902(-3)
45	-1.302 620 244 839(-2)	91	-2.956 361 127 784(-3)	137	-1.139 595 504 265(-3)
46	-1.245 283 703 557(-2)	92	-2.885 955 391 642(-3)		

Table 15

Relativistic magnetizabilities χ (in the units of $\alpha^2 a_0^3$) for states $1s_{1/2}$, $2s_{1/2}$, $2p_{1/2}$ and $2p_{3/2}$ of selected hydrogenlike ions, obtained with $\alpha^{-1} = 137.035\,999\,139$ (CODATA 2014) [the upper entries] and with $\alpha^{-1} = 137.035\,999\,074$ (CODATA 2010) [the lower entries].

Z	$1s_{1/2}$	$2s_{1/2}$	$2p_{1/2}$	$2p_{3/2} (\mu = \pm 1/2)$	$2p_{3/2} (\mu = \pm 3/2)$
1	-4.999 644 993 669(-1)	-6.999 722 649 147(+0)	6.676 163 152 752(+4)	-6.677 063 123 774(+4)	-5.999 861 546 894(+0)
	-4.999 644 993 668(-1)	-6.999 722 649 147(+0)	6.676 163 146 418(+4)	-6.677 063 117 440(+4)	-5.999 861 546 894(+0)
2	-1.249 645 001 764(-1)	-1.749 722 649 002(+0)	4.171 164 660 772(+3)	-4.173 414 370 995(+3)	-1.499 861 548 141(+0)
	-1.249 645 001 764(-1)	-1.749 722 649 002(+0)	4.171 164 656 814(+3)	-4.173 414 367 036(+3)	-1.499 861 548 141(+0)
5	-1.996 450 584 458(-2)	-2.797 226 479 764(-1)	1.065 244 131 032(+2)	-1.068 841 233 198(+2)	-2.398 615 568 695(-1)
	-1.996 450 584 455(-2)	-2.797 226 479 762(-1)	1.065 244 130 018(+2)	-1.068 841 232 184(+2)	-2.398 615 568 694(-1)
7	-1.016 859 395 768(-2)	-1.425 797 896 419(-1)	2.765 269 415 830(+1)	-2.783 607 783 733(+1)	-1.223 105 464 382(-1)
	-1.016 859 395 764(-2)	-1.425 797 896 416(-1)	2.765 269 413 192(+1)	-2.783 607 781 095(+1)	-1.223 105 464 381(-1)
10	-4.964 526 105 003(-3)	-6.972 264 418 235(-2)	6.600 466 097 095(+0)	-6.690 176 291 750(+0)	-5.986 158 805 136(-2)
	-4.964 526 104 969(-3)	-6.972 264 418 208(-2)	6.600 466 090 761(+0)	-6.690 176 285 416(+0)	-5.986 158 805 123(-2)
20	-1.214 607 414 490(-3)	-1.722 262 691 678(-2)	3.983 443 339 545(-1)	-4.205 544 369 778(-1)	-1.486 171 290 440(-2)
	-1.214 607 414 456(-3)	-1.722 262 691 651(-2)	3.983 443 335 588(-1)	-4.205 544 365 818(-1)	-1.486 171 290 427(-2)
40	-2.774 370 778 562(-4)	-4.097 522 252 752(-3)	2.149 268 284 498(-2)	-2.682 735 569 862(-2)	-3.612 214 346 049(-3)
	-2.774 370 778 233(-4)	-4.097 522 252 488(-3)	2.149 268 282 043(-2)	-2.682 735 567 380(-2)	-3.612 214 345 919(-3)
50	-1.651 892 129 562(-4)	-2.522 402 512 753(-3)	7.818 803 550 735(-3)	-1.112 807 953 802(-2)	-2.262 592 588 983(-3)
	-1.651 892 129 562(-4)	-2.522 402 512 490(-3)	7.818 803 540 792(-3)	-1.112 807 952 780(-2)	-2.262 592 588 854(-3)
80	-4.446 245 639 716(-5)	-8.150 967 719 944(-4)	6.338 207 576 445(-4)	-1.746 639 554 569(-3)	-8.017 538 525 544(-4)
	-4.446 245 636 709(-5)	-8.150 967 717 275(-4)	6.338 207 562 884(-4)	-1.746 639 552 928(-3)	-8.017 538 524 283(-4)
100	-1.749 820 929 318(-5)	-4.191 628 402 646(-4)	1.023 054 311 643(-4)	-7.040 609 243 754(-4)	-4.658 211 084 276(-4)
	-1.749 820 926 556(-5)	-4.191 628 399 901(-4)	1.023 054 307 216(-4)	-7.040 609 236 324(-4)	-4.658 211 083 045(-4)
120	-3.838 526 853 900(-6)	-1.990 375 839 852(-4)	-8.557 571 732 907(-6)	-3.048 757 238 860(-4)	-2.844 509 502 864(-4)
	-3.838 526 830 112(-6)	-1.990 375 836 816(-4)	-8.557 571 841 886(-6)	-3.048 757 234 136(-4)	-2.844 509 501 672(-4)
130	2.099 852 117 594(-7)	-1.184 030 625 960(-4)	-1.633 283 429 506(-5)	-1.847 126 573 331(-4)	-2.239 544 235 860(-4)
	2.099 852 324 002(-7)	-1.184 030 622 281(-4)	-1.633 283 430 519(-5)	-1.847 126 567 976(-4)	-2.239 544 234 690(-4)
137	2.154 582 953 028(-6)	-4.903 302 713 912(-5)	-9.398 566 990 645(-6)	-4.903 236 487 356(-5)	-1.894 662 493 029(-4)
	2.154 582 969 088(-6)	-4.903 302 402 152(-5)	-9.398 566 418 109(-6)	-4.903 235 281 066(-5)	-1.894 662 491 876(-4)